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Utility Patent Application

CONTEXT SENSITIVE CAMERA

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CONTEXT SENSITIVE CAMERA

Technical Field

The invention relates generally to image understanding, and more particularly to context sensitive camera systems.

Description

“Image understanding” refers to identifying objects in still or moving images. For example, military technologies have long been directed toward identifying buildings, planes, ships, artillery, etc. in images captured by satellites or spy planes. In other applications, image understanding is useful in annotating images with contextual information for the purpose of supporting indexing and searching of image databases. For example, images on the Web may be indexed on the basis of rich contextual information to support powerful image searching applications – e.g., searching for images containing a “Sony DCR-TRV20 Handycam”. Typically, such contextual information is provided in association with the image through manual identification of objects in the image. Other applications in which image understanding is useful include without limitation vehicle routing, industrial inspections, medical analysis, and surveillance.

In many image understanding applications, identification of objects in an image is accomplished by way of two dimensional (2D) and three dimensional (3D) modeling techniques, in which an image is compared with models of possible objects in the image. When such comparisons result in a “good” match between a model and the image, the object associated with the model is deemed to be present in the image. For example, if a model of a particular model of battleship results in

1 a good match with a portion of an image, that portion of the image is deemed to
2 include that type of battleship.

3 The effectiveness and efficiency of such applications are generally
4 dependent upon the availability of appropriate models for objects in the image, the
5 size of the model library, and the matching technology. However, existing
6 approaches require significant computing resources to ensure acceptable matching
7 accuracy over all possible models, in large part because the scope of possible
8 objects in a generic image requires such a large library of models.

9 Implementations described and claimed herein enhance the effectiveness
10 and efficiency of image understanding applications by providing context for
11 images. In one implementation, objects in the image are capable of identifying
12 themselves to the image capture device. The identifications may then be used to
13 identify specific models needed to match possible objects in the image. For
14 example, the identification of a particular model of video camera indicates that a
15 specific model for that type of camera should be used in the evaluating the image.
16 In addition, the identifications may also be used to narrow the library of models
17 needed to match possible objects in the image. For example, identification of a
18 desktop computer, a desk telephone, and a fax machine can suggest an office
19 setting. Therefore, the library of possible objects may be narrowed to exclude
20 most outdoor-oriented models or to include predominantly office-related objects.
21 Narrowing the scope of possible models to consider can dramatically improve the
22 effectiveness and efficiency of image understanding applications in these
23 environments.

24 In various implementations, articles of manufacture are provided as
25 computer program products. One implementation of a computer program product

1 provides a computer program storage medium readable by a computer system and
2 encoding a computer program. Another implementation of a computer program
3 product may be provided in a computer data signal embodied in a carrier wave by
4 a computing system and encoding the computer program.

5 The computer program product encodes a computer program for executing
6 on a computer system a computer process that requests identification of one or
7 more objects in association with a capture of an image. An identifier is received,
8 responsive to the requesting operation. The identifier identifies an object in the
9 image.

10 In another implementation, a method is provided. Identification of one or
11 more objects is requested in association with a capture of an image. An identifier
12 is received, responsive to the requesting operation. The identifier identifies an
13 object in the image.

14 In yet another implementation, a system is provided that includes a
15 signaling module coupled to a digital capture device. The signaling module
16 requests identification of one or more objects in association with a capture of an
17 image. The signaling module receives an identifier identifying an object in the
18 image, responsive to requesting identification.

19 In yet another implementation, a computer program product encodes a
20 computer program for executing on a computer system a computer process that
21 receives a request for identification from an image capture device. Identification
22 information associated with an active object is collected and transmitted from the
23 active object to the image capture device.

24 In yet another implementation, a method is provided that receives a request
25 for identification from an image capture device. Identification information

1 associated with an active object is collected and transmitted from the active object
2 to the image capture device.

3 In yet another embodiment, a system is provided that includes a detection
4 module of an active object that receives a request for identification from an image
5 capture device. A collection module of the active object collects identification
6 information associated with the active object. A transmission module of the active
7 object transmits the identification information to the image capture device.

8 Other implementations are also described and recited herein.

9 Brief descriptions of the drawings included herein are listed below.

10 FIG. 1 illustrates an exemplary context sensitive camera system.

11 FIG. 2 illustrates exemplary operations for capturing an image with context
12 information.

13 FIG. 3 illustrates exemplary operations for identifying an object to a
14 context sensitive camera.

15 FIG. 4 illustrates an exemplary system useful for implementing an
16 embodiment of the present invention.

17 In one implementation, a communications protocol is established between
18 image capture devices (e.g., still cameras, video cameras, infrared sensors, etc.)
19 and objects that may be in an environment. Such objects can therefore respond to
20 requests for identification by the image capture device, even though the
21 responding object may be outside the image capture frame (e.g., behind the
22 camera).

23 In addition, in some implementations, such objects may also include objects
24 that "respond" by delegation. For example, if one object is a desktop computer,
25 the desktop computer may also know that it is connected to a keyboard, a mouse

1 and a printer, and possibly the models, locations, and configurations of those
2 connected devices. These devices may not inherently have the ability to respond
3 to a request for identification. Therefore, the desktop computer may communicate
4 to the image capture device what it knows about these connected objects

5 FIG. 1 illustrates an exemplary context sensitive camera system 100. An
6 image capture device 102, such as a still camera, a video camera, etc., is coupled
7 to an image capture module 104, which processes an image captured by the image
8 capture device 102. It should be understood that the coupling between
9 components of the system 100 may be accomplished by wired connections,
10 wireless connections (e.g., radio frequency or infrared), or by storage and transfer
11 (e.g., capturing an image into a flash memory and downloading the image into the
12 image capture module or one of the other modules). The image capture
13 module 104 controls the triggering of the image capture device 102 and receipt of
14 the captured image. It should also be understood that the image capture
15 device 102 may capture moving images. Therefore image capture events may be
16 periodic or continuous.

17 In association with the image capture, a signaling module 106 transmits one
18 or more identification requests to objects in the environment. In one
19 implementation, such transmission may employ various wireless communications
20 protocols, such as Bluetooth, GSM, GPRM, GPRS and the various versions
21 of 802.11. However, in other implementations, infrared communications, various
22 wired communications, and other communication means may be employed.

23 In various implementations, request triggers may occur periodically or may
24 be manually or automatically initiated on a non-periodic schedule. For example,
25 requests may be transmitted after a certain number of frames. Alternatively, the

1 requests may be triggered when a scene changes so significantly that the
2 videographer wants a new identification performed. In this manner, the objects
3 identified in a video sequence can change as the scene changes.

4 Objects 108 in the environment 110 receive the request and collect
5 identification information for themselves and their delegate objects. In one
6 implementation, identification information is communicated to the signaling
7 module 106 in an identification message and may include identifiers (IDs) of the
8 objects as well as parameters describing the objects, their locations, or their
9 configurations. For example, a laptop object 112 may identify itself as a "Dell
10 C400" (or some ID representing a "Dell C400" or comparable model). In
11 addition, the laptop object 112 may also provide identification information relating
12 to its location in a building or in a room. Such location information may also be
13 geographical in nature (e.g., in a specified city or country). Other identification
14 information may specify the configuration of the laptop object 112, including
15 whether it is opened or closed, whether it is in a docking station, etc. A cellphone
16 object 114 capable of responding is also shown in environment 110.

17 A desktop computer object 116 illustrates couplings to delegate objects,
18 including a keyboard 118, a mouse 118, and a printer 120. In some
19 implementations, identification information for such delegate objects may be
20 included as configuration information in the identification information returned by
21 the desktop computer object 116. In alternative implementations, however, the
22 identification information for such delegate objects may be transmitted by the
23 desktop computer object 116 in individual information messages for each delegate
24 object or in one or more group information messages for multiple delegate objects.

1 The desktop computer object 116 may also maintain identification
2 information for the delegate objects in a datastore (not shown) and/or may
3 dynamically determine identification information for those delegate objects in the
4 vicinity in response to the request of the signaling module 106. For example, the
5 desktop computer object 116 may record identification information for objects
6 attached to it as such objects are installed and connected. Alternatively, the
7 desktop computer object 116 may query devices attached to it in response the
8 request, such as by querying devices on a peripheral bus or through an infrared
9 communication.

10 After the signaling module 106 receives the identification message or
11 messages from the objects in the environment 110, the identification information
12 is received by an object matching module 122. In one embodiment, the
13 identification information may, at this point, be stored in association with the
14 image. Evaluating the image and the identification information for the purposes of
15 accurate image understanding can take place later, or not at all, depending on the
16 needs of the user. For example, it may be enough to know that the image was
17 taken in the proximity of the object, whether or not the object was actually
18 captured in the image.

19 In another implementation, the image data captured by the image capture
20 module 104 is also received by the object matching module 122. The object
21 matching module 122 sends the identification information to a model
22 extractor 124, which uses the identification information to extract models for
23 identified objects or for objects associated with identified objects from a model
24 datastore 126. For example, objects relating to an indoor scene may cause exterior
25 models to be excluded from those returned to the object matching module 122.

1 The model datastore 126 may include various types of models, including two
2 dimensional models and three dimensional models. In addition, the model
3 extractor 124 may also parameterize the models to specialize them. For example,
4 the model for the laptop object 112 may be parameterized to match a closed laptop
5 device as opposed to an open laptop device.

6 Likewise, the other parameters that may be used to narrow the model set
7 may be received to a sub-portion of possible models for a given identification. For
8 example, based on identification of a computer, parameters identifying the object
9 as a "Dell"-branded computer can specify that only Dell-appropriate models
10 should be used, rather than using a generic set of models for all computers. In one
11 implementation, by determining that the computer is a Dell system may allow the
12 object matching module 126 to access the Dell-appropriate models directly or
13 indirectly from the vendor (e.g., a Dell website or database).

14 Furthermore, a hierarchy of models may be used, wherein knowing that the
15 object is a Dell computer, a base model for a laptop may be used to roughly
16 identify the object as a Dell laptop computer. Thereafter, more specialized models
17 for each specific type/configuration of Dell laptop computer may be used to
18 further refine the identification. In this manner, identification through image
19 understanding may be provided at various levels of detail.

20 The object matching module 122 matches the extracted models to objects
21 responding to the request. However, some objects that are not actually in the
22 image may have responded to the request. For example, some responding objects
23 may be positioned behind the image capture device or otherwise out of frame.
24 Therefore, the object matching module 122 attempts to determine which objects
25 are actually in the image by evaluating the image data against the models and

1 generates parameters identifying and/or describing the objects in the image (e.g.,
2 using keywords, reference numbers, etc.).

3 An image storage module 128 receives the image data and parameters
4 identifying the matched objects and stores the parameters in association with the
5 image data in an image store 130. For example, as shown in data 132, the
6 parameters may be combined in a single file or data object. In contrast, the image
7 data and the parameters may be stored in a database with associations between
8 them. Other associated storage schemes are also contemplated. Furthermore, in
9 the case of video images, the multiple sets of parameters may be stored at offsets
10 within the video image file to provide accurate identification information for
11 different scenes.

12 FIG. 2 illustrates exemplary operations 200 for capturing an image with
13 context information. A capture operation 202 captures an image, such as by
14 digital imaging or photographic techniques. A transmission operation 204
15 transmits a request for identification to objects in the environment. It should be
16 understood that operations 202 and 204 may be reversed in order or may occur
17 concurrently. Objects capable of responding to the request do so, and the
18 responsive identification information is received by a receiving operation 206.
19 Again, in one implementation, storing the received identification information in
20 association with the image is useful, even without the image understanding
21 operations. Therefore, a storage operation following the receiving operation 206
22 may be employed before terminating the process.

23 In another implementation, the exemplary process continues with a
24 registration operation 208 that associates the received identification information
25 with the image data. In one implementation, the digital image data and the

1 identification information are associatively stored in temporary storage. However,
2 in the case of photographic images, some manner of cross-referencing between a
3 film negative and the identification information may be employed (e.g., a database
4 associating file indices with the identification information for each image).

5 An extraction operation 210 extracts relevant models from a model
6 datastore. In one implementation, the extraction operation 210 extracts models for
7 objects identified in the identification information. In addition, groups of models
8 may be extracted from the model datastore, thus narrowing the number of models
9 required by an object matching operation 212. For example, based on the
10 identification information, a sub-portion of indoor models may be extracted
11 whereas outdoor models may be excluded. This improves the efficiency and
12 effectiveness of object identification.

13 The object matching operation 212 evaluates the image using the extracted
14 models and generates parameters for the objects identified in the image. An
15 annotation operation 214 associatively stored the parameters with the image.

16 FIG. 3 illustrates exemplary operations 300 for identifying an object to a
17 context sensitive camera. A detection operation 302 detects a request for
18 identification of the object. For example, a cell phone may detect the request over
19 a GSM channel or a laptop computer may detect the request over a WiFi channel.

20 A collection operation 304 collects identification information of the object
21 and that of other objects of which it is aware. For example, the responding object
22 may be aware of other attached devices or devices in its proximity and can
23 respond with identification information for those devices as well. Alternatively or
24 additionally, the object may query other devices to learn what objects are in the
25 proximity. The identification information for these objects are collected in the

1 collection operation 304 and transmitted to the image capture system in a
2 transmitting operation 306.

3 The exemplary hardware and operating environment of FIG. 4 for
4 implementing the invention includes a general purpose computing device in the
5 form of a computer 20, including a processing unit 21, a system memory 22, and a
6 system bus 23 that operatively couples various system components include the
7 system memory to the processing unit 21. There may be only one or there may be
8 more than one processing unit 21, such that the processor of computer 20
9 comprises a single central-processing unit (CPU), or a plurality of processing
10 units, commonly referred to as a parallel processing environment. The computer
11 20 may be a conventional computer, a distributed computer, or any other type of
12 computer; the invention is not so limited.

13 The system bus 23 may be any of several types of bus structures including a
14 memory bus or memory controller, a peripheral bus, and a local bus using any of a
15 variety of bus architectures. The system memory may also be referred to as
16 simply the memory, and includes read only memory (ROM) 24 and random access
17 memory (RAM) 25. A basic input/output system (BIOS) 26, containing the basic
18 routines that help to transfer information between elements within the computer
19 20, such as during start-up, is stored in ROM 24. The computer 20 further
20 includes a hard disk drive 27 for reading from and writing to a hard disk, not
21 shown, a magnetic disk drive 28 for reading from or writing to a removable
22 magnetic disk 29, and an optical disk drive 30 for reading from or writing to a
23 removable optical disk 31 such as a CD ROM or other optical media.

24 The hard disk drive 27, magnetic disk drive 28, and optical disk drive 30
25 are connected to the system bus 23 by a hard disk drive interface 32, a magnetic

1 disk drive interface 33, and an optical disk drive interface 34, respectively. The
2 drives and their associated computer-readable media provide nonvolatile storage
3 of computer-readable instructions, data structures, program modules and other
4 data for the computer 20. It should be appreciated by those skilled in the art that
5 any type of computer-readable media which can store data that is accessible by a
6 computer, such as magnetic cassettes, flash memory cards, digital video disks,
7 Bernoulli cartridges, random access memories (RAMs), read only memories
8 (ROMs), and the like, may be used in the exemplary operating environment.

9 A number of program modules may be stored on the hard disk, magnetic
10 disk 29, optical disk 31, ROM 24, or RAM 25, including an operating system 35,
11 one or more application programs 36, other program modules 37, and program
12 data 38. A user may enter commands and information into the personal computer
13 20 through input devices such as a keyboard 40 and pointing device 42. Other
14 input devices (not shown) may include a microphone, joystick, game pad, satellite
15 dish, scanner, or the like. These and other input devices are often connected to the
16 processing unit 21 through a serial port interface 46 that is coupled to the system
17 bus, but may be connected by other interfaces, such as a parallel port, game port,
18 or a universal serial bus (USB). A monitor 47 or other type of display device is
19 also connected to the system bus 23 via an interface, such as a video adapter 48.
20 In addition to the monitor, computers typically include other peripheral output
21 devices (not shown), such as speakers and printers.

22 The computer 20 may operate in a networked environment using logical
23 connections to one or more remote computers, such as remote computer 49. These
24 logical connections are achieved by a communication device coupled to or a part
25 of the computer 20; the invention is not limited to a particular type of

1 communications device. The remote computer 49 may be another computer, a
2 server, a router, a network PC, a client, a peer device or other common network
3 node, and typically includes many or all of the elements described above relative
4 to the computer 20, although only a memory storage device 50 has been illustrated
5 in FIG. 4. The logical connections depicted in FIG. 4 include a local-area network
6 (LAN) 51 and a wide-area network (WAN) 52. Such networking environments
7 are commonplace in office networks, enterprise-wide computer networks, intranets
8 and the Internet, which are all types of networks.

9 When used in a LAN-networking environment, the computer 20 is
10 connected to the local network 51 through a network interface or adapter 53,
11 which is one type of communications device. When used in a WAN-networking
12 environment, the computer 20 typically includes a modem 54, a type of
13 communications device, or any other type of communications device for
14 establishing communications over the wide area network 52. The modem 54,
15 which may be internal or external, is connected to the system bus 23 via the serial
16 port interface 46. In a networked environment, program modules depicted relative
17 to the personal computer 20, or portions thereof, may be stored in the remote
18 memory storage device. It is appreciated that the network connections shown are
19 exemplary and other means of and communications devices for establishing a
20 communications link between the computers may be used.

21 In an exemplary implementation, a signaling module, an image capture
22 module, a registration module, a model extractor, and an object matching module,
23 and other modules may be incorporated as part of the operating system 35,
24 application programs 36, or other program modules 37. The object identifiers, the
25 parameters, and the image data may be stored as program data 38.

1 The embodiments of the invention described herein are implemented as
2 logical steps in one or more computer systems. The logical operations of the
3 present invention are implemented (1) as a sequence of processor-implemented
4 steps executing in one or more computer systems and (2) as interconnected
5 machine modules within one or more computer systems. The implementation is a
6 matter of choice, dependent on the performance requirements of the computer
7 system implementing the invention. Accordingly, the logical operations making
8 up the embodiments of the invention described herein are referred to variously as
9 operations, steps, objects, or modules.

10 The above specification, examples and data provide a complete description
11 of the structure and use of exemplary embodiments of the invention. Since many
12 embodiments of the invention can be made without departing from the spirit and
13 scope of the invention, the invention resides in the claims hereinafter appended.
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